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CIRCUIT ANALYSIS AND USES OF AN ELECTRIC SLEEP APPARATUS

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6571st Aeromedical Research Laboratory
Aerospace Medical Division
Air Force Systems Command
Holloman Air Force Base, New Mexico

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FOREWORD

The device described herein was obtained through the efforts of LtCol Lauritz Larsen and staff of the Deputy for Foreign Technology, Air Force Missile Development Center, Holloman Air Force Base, New Mexico.

Analysis was provided by Mr. James A. Merritt, under the supervision of Mr. Mac Connell, of the Aeromed Sub-Group, Land-Air (a Division of Dynalectronic Corp.).

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This abstract is classified Confidential.

ABSTRACT

The "Electrosone" demonstrated at the Brussels World's Fair, 1958, was obtained. An electrical circuit analysis of this electrically induced sleep machine is presented and the applications of this machine are discussed.

PUBLICATION REVIEW

This Technical Documentary Report has been reviewed and is approved.

Hamilton H Blackshear
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CIRCUIT ANALYSIS AND USES OF AN ELECTRIC SLEEP APPARATUS

I. INTRODUCTION

For over 25 years various Russian investigators have worked on the subject of electrical anesthesia. A portable device, field tested and apparently practical, was demonstrated in the USSR section of the Brussels Universal and International Exhibition in 1958. This device was recently obtained by the Foreign Technology Division, AFSC, upon the request of the author.

II. METHOD OF EXPLOITATION

Upon receipt of the machine, the White Sands Missile Range - 6571st ARL contract facility (Land-Air; Aeromed Sub-Group) was notified. Mr. James Merritt of that group has completed a circuit analysis which is the subject of this report.

The details of a prolonged use, normal saline skin electrode system used with this machine are under preparation for publication. These electrodes are a definite advance in the state of the art, since they permit wear for several days.

The use of this device in the handling of large and potentially dangerous animals such as bears and mature chimpanzees is programmed in the near future.

A detailed analysis, complete with Chinese-copy production, of the components not available on the open US market is being requested of the appropriate FTD facilities.

Clinical exploitation and evaluation is not within the management scope of the 6571st ARL, and will in large part be given to other Aerospace Medical Division facilities; however, as time permits, this application will be studied.

III. RESULTS

The circuit analyses, shown in the following figure, are described by Mr. Merritt in the Appendix.

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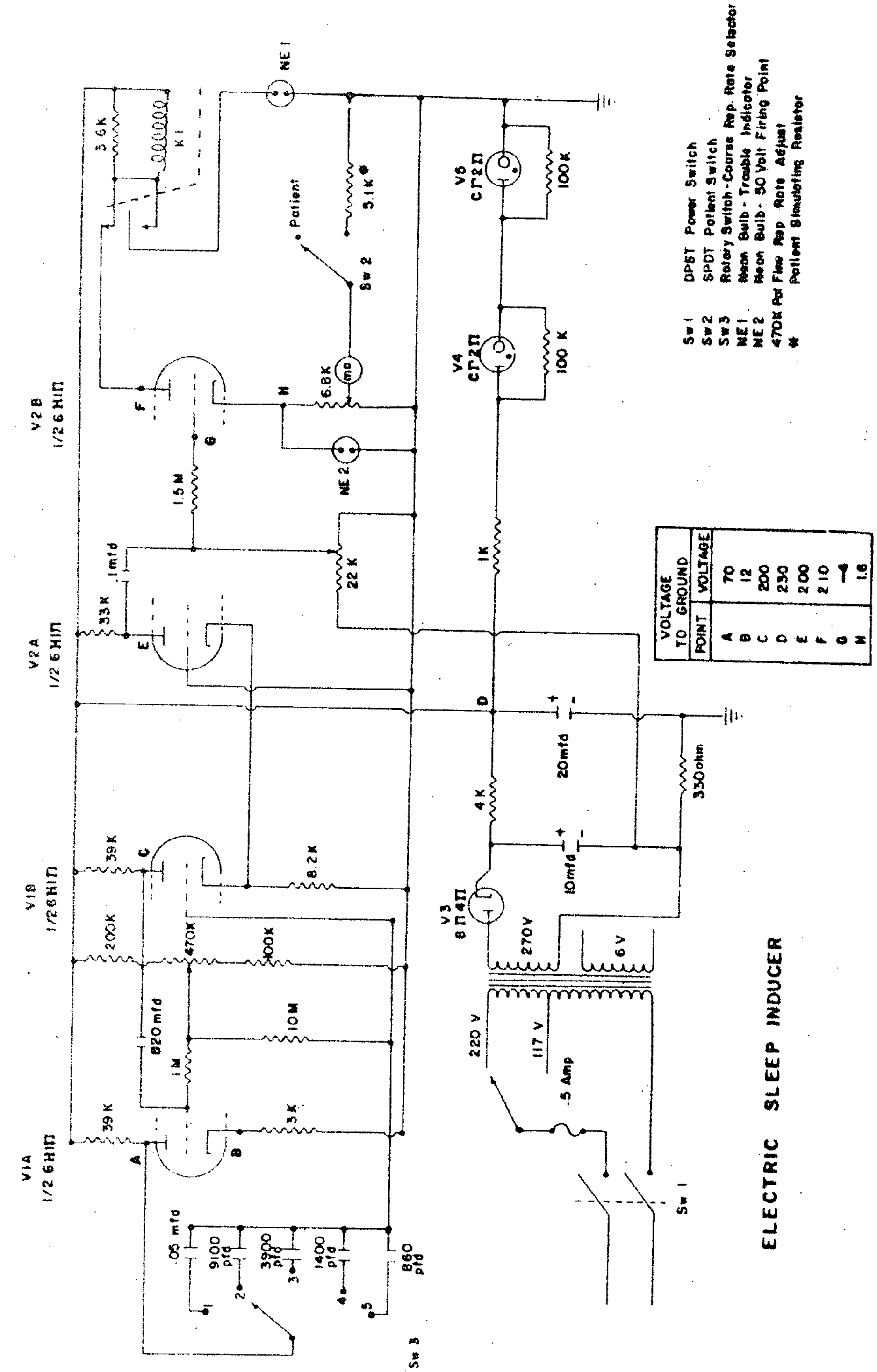

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IV. DISCUSSION

The circuit analysis confirms the published Russian data of the past five years that the electrical circuits produce square wave pulses superimposed on a DC component. This type of current could well have effects quite different from those of the sine-wave currents used by American anesthesiologists who found such anesthesia to be possible but not practical.

The device cannot be constructed exactly with American manufactured components, but fabrication of these components appears to be easy to accomplish. Since widespread clinical evaluation appears warranted, several tubes of each type used will be obtained.

V. CONCLUSIONS

A Russian-built electrical sleep apparatus was obtained and subjected to circuit analysis. The following are concluded:

1. The device can be assembled only after fabrication of several components not readily available.

2. The device produces pulses as described in the open Russian medical literature for use in electric sleep and anesthesia.

3. Skin electrodes used with this machine are in themselves worthy of detailed exploitation and use.

4. The machine and components are well constructed.

5. Exploitation of use, both clinical and experimental, is warranted.

ARL-TDR-63-4

APPENDIX

PART I - GENERAL DESCRIPTION

1. Circuitry:

Essentially a pulse generator with a continuously variable pulse repetition rate, from 2 to 140 pulses per second. The pulse duration varies from .6 to 1.6 milliseconds as explained in Part III, Output. The output is direct coupled to the patient, in order that the pulses may be superimposed on a controllable direct component. This DC component may be continuously monitored by means of the meter on the front panel, which reads one milliampere full scale. There are no direct means for monitoring the pulse output provided with the instrument. There are two safety devices incorporated in the instrument designed to protect the patient from electrical shock. (These safety devices are evaluated as to their workability under Part II, Circuit Operation. This is not to be construed as an evaluation that the limits of patient dosage are safe. This is simply an evaluation of what the machine will do in case of malfunction.)

2. Parts and Materials:

The materials and components used in the machine are apparently of high quality throughout. Direct replacement with American components would pose some problems. However, there is nothing involved in the basic circuit that could not be duplicated if the need should arise.

3. Workmanship:

The instrument is well constructed comparable to American procedures of circuit layout. Workmanship is very good throughout.

4. Controls - Front Panel:

Power Switch - Mounted in the right center of the front panel.

Function: Turns on all power to the instrument.

Fuse - Right-hand side below the power switch.

Function: Fuses the power input. The fuse holder is so constructed that one can switch power inputs from 117 volts to 220 volts by turning the arrow of the fuse insert to the indicated voltages marked above and below the holder.

Ground Connection - Upper right-hand side of panel.

Function: Connected to the instrument chassis and to the patient via one set of patient leads. Should be connected to a good earth ground.

Fine Tuning - Upper right-hand corner of panel, marked with arbitrary 0 - 25 markings.

Function: Gives continuous pulse repetition rate control on each of the five positions of the coarse tuner.

Coarse Tuner - Right center of panel, marked with five positions from 1 - 5.

Function: Provides coarse adjustments of pulse repetition rates in steps.

Patient Switch - Toggle switch immediately to the right of the milliampere meter.

Function: Switches the instrument output from the patient to a patient simulating resistor. For initial instrument setup, "down" position is the patient position; "up" position is the resistor.

Output Control - Immediately below the panel meter. Arbitrary markings of 0 to 25.

Function: Controls patient dosage of both pulse amplitude and DC component amplitude.

Milliammeter - Panel meter left side of panel. One milliampere full scale.

Function: The meter is in series with either the patient or the patient simulating resistor, as switched into the circuit. Measures ONLY the DC component of patient dosage.

White Light - Upper left-hand corner of panel.

Function: Pilot light; indicates power is on.

Red Light - Upper left-hand corner of panel.

Function: Trouble indicator. The patient should be disconnected if this light comes on. If this light actuates, it will remain actuated until power to the instrument is removed.

Output Jack - Polarized jack below the panel meter.

Function: Mates with the plug on the patient leads.

Bias Control - Internal screwdriver controlled potentiometer. Not available from the front panel.

Function: Controls the bias on the output tube and therefore controls the percentage of the DC current level of the patient dosage. Does not control pulse amplitude level.

PART II - CIRCUIT OPERATION

1. Power Supply:

The power supply is a transformer half-wave design, with voltage regulation. The transformer primary is tapped to permit either 117 or 220 volt AC operation. There are two secondary windings, one is a six-volt winding providing filament power. The high voltage winding is 270 volts, not center tapped. V-3 is a full-wave rectifier tube connected for half-wave operation. V-4 and V-5 are voltage regulator tubes connected in series used to regulate B plus at 230 volts. A negative bias voltage for the output tube is developed by inserting a 330 ohm resistor between the negative side of the transformer and ground.

2. Pulse Generator:

Tubes V1A and V1B operate as an unstable multi-vibrator, which has an inherently fast rise time and a relatively short pulse duration. The pulse repetition rate is controlled in steps by changing the coupling between the plate of V1A and the grid of V1B. The discharge path of this coupling capacitor is through a 10 megohm resistor, through a part of the 470K ohm vernier control, and through a 100K resistor to ground. Vernier rate control is provided by controlling the bias on each tube, which changes the firing point of the multi-vibrator. This is accomplished through a voltage divider consisting of a 200K ohm resistor, a 470K potentiometer, and a 100K resistor between B plus and ground.

The output of the multi-vibrator is cathode coupled to V2A, by means of the common 8.2K resistor. V2A is used as a limiter and shaper. The inherently fast rise time of the multi-vibrator is further enhanced by the limiter; the top is squared off at the same time.

The output of V2A is capacity coupled to the grid of the output tube V2B. This tube is biased to near cutoff by means of a bias supply, which is controlled with a 22K ohm potentiometer, not available at the front panel. The bias supply is needed because the output DC component is taken from the cathode of V2B, therefore the voltage here must be controlled at a very low level. The setting of the bias on V2B controls the percentage of DC component in the patient dosage.

3. Safety Devices:

There are two safety devices incorporated in the instrument designed to protect the patient. The following is an analysis of the method of operation and the operating points of these two safety devices, and are not intended to be an evaluation as to whether the operating points of the devices are within safe limits of patient tolerances of electric current.

A: The cathode of V2B (from which the output is obtained) is shunted with a neon bulb. The firing point of this bulb is 50 volts. In the event of circuit malfunction, the voltage available at the cathode would not exceed 50 volts, depending on the setting of the output level control.

B: The plate circuit of V2B consists of the coil of K-1 and a 3.6K ohm resistor in parallel. When the plate current of V2B reaches 15 ma, K-1 will key. This removes plate voltage from V2B, removing voltage from the patient. When K-1 keys, its coil is placed in series with the trouble lamp, holding the relay keyed until power is turned off.

PART III - OUTPUT

The output consists of pulses superimposed on a DC component. The pulses have a rise time of 6 microseconds and a decay time of 1 microsecond. Pulse repetition may be varied continuously from 2 P/S to 140 P/S. There is no appreciable change in rise or decay time with a change of repetition rate. Pulse duration varies with the setting of the vernier control. This change (.6 to 1 millisecond going from 0 to 25 on the vernier control) is approximately the same for all positions of the coarse control except for position one. For position one on the coarse control the change in pulse duration varies from .8 to 1.6 milliseconds, from 0 to 25 respectively, on the vernier control.

The obtainable P/S for the five settings of the coarse control are as follows:

Position 1 - 2 to 8 P/S.
Position 2 - 8 to 16 P/S.
Position 3 - 16 to 32 P/S.
Position 4 - 32 to 60 P/S.
Position 5 - 60 to 140 P/S.

Following is a table of observed outputs, obtained by using resistors to simulate a patient. These results were obtained with the bias on the output tube set at the same level as when the instrument was received. Decreasing this bias setting will increase the percentage DC component and the amplitude of the composite wave.

TABLE OF OBSERVED OUTPUTS

Simulating Resistance	Setting of Output Control	Composite Amplitude	DC Voltage Component	Patient Current
1K	12.5	3.2 volts	.7 volts	.3 ma
	25	14.0 "	.5 "	.95 "
2K	12.5	5.0 "	.5 "	.25 "
	25	16.0 "	.9 "	.65 "
3K	12.5	5.9 "	.5 "	.2 "
	25	16.0 "	1.25 "	.5 "
4K	12.5	6.0 "	.5 "	.15 "
	25	17.0 "	1.5 "	.4 "
5.1K*	12.5	7.0 "	.5 "	.15 "
	25	17.0 "	1.5 "	.3 "
6K	12.5	7.0 "	1.5 "	.1 "
	25	18.0 "	1.5 "	.3 "
7K	12.5	7.2 "	1.5 "	.1 "
	25	18.0 "	1.5 "	.25 "
8K	12.5	8.0 "	1.5 "	.1 "
	25	18.5 "	1.6 "	.2 "
9K	12.5	8.0 "	1.6 "	.09 "
	25	18.5 "	1.6 "	.2 "
10K	12.5	8.0 "	1.6 "	.08 "
	25	18.5 "	1.6 "	.18 "

*This is the internal patient simulating resistor used for setting up the instrument.

PART IV - CONCLUSIONS

This report is not an attempt to evaluate the clinical merits of this instrument, neither its sleep inducing qualities, nor, from the standpoint of safety, of its use. This is a report only of technical electronic capabilities of this particular instrument as the instrument was received by us. There is no known technical information available to us concerning either operating procedures or lead placement on the patient. We have no information that the observed outputs are the correct ones needed for the inducement of sleep, in either waveshape or amplitude of the composite wave.

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